



Data User Guide

GPM Ground Validation National Mosaic and Multi-Sensor QPE (NMQ) System IPHEX

Introduction

The GPM Ground Validation National Mosaic and Multi-Sensor QPE (NMQ) System IPHEX dataset consists of six different data products: precipitation rate, hourly rainfall accumulation, daily rainfall accumulation, hybrid scan reflectivity, three-dimensional reflectivity, and vertically integrated liquid content estimates. These data products were created using the NOAA NMQ System which ingests Weather Surveillance Radar 88 Doppler (WSR-88D) radar data, Rapid Update Cycle (RUC) model analysis fields, and Hydrometeorological Automated Data Systems (HADS) gauge data. The files provided in this dataset are from system output during the GPM Integrated Precipitation and Hydrology Experiment (IPHEX) field campaign that occurred in the Southern Appalachians, spanning into the Piedmont and Coastal Plain regions of North Carolina. These data are available in ASCII and netCDF-4 formats for dates between April 30, 2014 through June 16, 2014.

Notice:

It is requested that users refer to the National Oceanic and Atmospheric Administration's (NOAA)/National Severe Storm Sentinel's (NSSL's) National Mosaic and QPE system when using or presenting these data in any public or scientific forum including conferences, workshops, meetings, technical reports, and publications. **Details of data use requirements are provided [below](#).**

Citation

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<http://dx.doi.org/10.5067/GPMGV/IPHEX/NMQ/DATA101>

Keywords:

NASA, GHRC, IPHEX, GPM, NMQ, North Carolina, rain rate, precipitation rate, hourly rain accumulation, daily rain accumulation, hybrid scan reflectivity, 3-D reflectivity, vertically integrated liquid content

Campaign

The GPM Ground Validation campaign used a variety of methods for validation of GPM satellite constellation measurements prior to and after launch on the GPM Core Satellite, which launched on February 27, 2014. The instrument validation effort included numerous GPM-specific and joint-agency/international external field campaigns, using state of the art cloud and precipitation observational infrastructure (polarimetric radars, profilers, rain gauges, and disdrometers). These field campaigns accounted for the majority of the effort and resources expended by the GPM Ground Validation mission. More information about the GPM Ground Validation mission is available at <https://pmm.nasa.gov/index.php?q=science/ground-validation>.

One of the GPM Ground Validation field campaigns was the GPM IPHEX, which was held in North Carolina during 2014 with an intense study period from May 1 to June 15, 2014. The goal of the IPHEX campaign was to contribute to the development, evaluation, and improvement of remote sensing precipitation algorithms in support of the GPM mission through NASA GPM Ground Validation field campaign (IPHEX_GVFC) and the evaluation of Quantitative Precipitation Estimation (QPE) products for hydrological forecasting and water resource applications in the Upper Tennessee, Catawba-Santee, Yadkin-Pee Dee, and Savannah river basins (IPHEX-HAP, H4SE). NOAA Hydrometeorology Testbed (HTM) has synergy with this project. More information about IPHEX is available at <http://gpm.nsstc.nasa.gov/iphex/>.

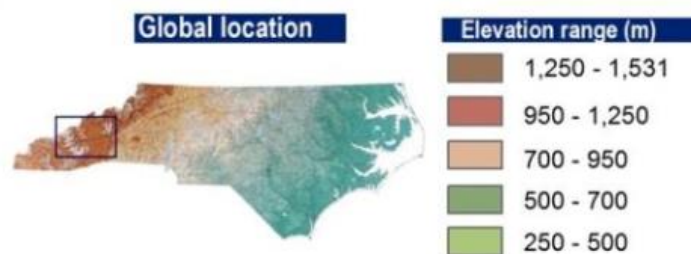


Figure 1: Region of North Carolina IPHEX campaign ground validation
(image source: <http://gpm-gv.gsfc.nasa.gov/Gauge/>)

Product Description

The National Mosaic and Multi-Sensor QPE (NMQ) System is a fully automated, multiradar, multisensor system which was used to assimilate different observational networks in an effort to create high-resolution national 3D grids of radar reflectivity for numerical weather

prediction model verification, data assimilation, and aviation product development, as well as for creating high-resolution national multisensor QPEs for flash flood and flood warnings and water resource management. The NMQ System ingests data from 140 Weather Surveillance Radar 88 Doppler (WSR-88D) radars, Rapid Update Cycle (RUC) model analysis fields, and Hydrometeorological Automated Data Systems (HADS) gauge data. More information about the RUC is available in [Benjamin et al., 2004](#).

The NMQ System product has six different outputs including rain rate estimates, hourly rain accumulation, daily rain accumulation, vertically integrated liquid content, hybrid scan reflectivity, and three-dimensional reflectivity. These products are gridded at a spatial resolution of 0.01 x 0.01 degrees over five minute intervals. More information about the NMQ System and its output products are available in [Zhang et al., 2011](#).

Investigators

Pierre-Emmanuel Kirstetter
NOAA/National Severe Storms Laboratory
Norman, Oklahoma

Jonathan J. Gourley
NOAA/National Severe Storms Laboratory
Norman, Oklahoma

Data Characteristics

The GPM Ground Validation National Mosaic and Multi-Sensor QPE (NMQ) System IPHEX dataset consists of precipitation rate, hourly rainfall accumulation, daily rainfall accumulation, hybrid scan reflectivity, three-dimensional reflectivity, and vertically integrated liquid content estimates. These data products are considered Level 4 products. More information about the NASA data processing levels are available on the [NASA Data Processing Levels website](#).

Table 1: Data Characteristics

Characteristic	Description
Platform	Ground stations
Instruments	WSR-88D, Canadian C-band radars, HADS gauges
Projection	n/a
Spatial Coverage	N: 38.705, S:32.700, E: -78.695, W: -87.100 (North Carolina)
Spatial Resolution	0.01x0.01 degrees
Temporal Coverage	April 30, 2014 - June 16, 2014
Temporal Resolution	hourly-daily
Sampling Frequency	5 minutes
Parameter	Precipitation rate, hourly rainfall accumulation, daily rainfall accumulation, hybrid scan reflectivity, 3-D reflectivity, vertically integrated liquid content

Version	1
Processing Level	4

File Naming Convention

The GPM Ground Validation National Mosaic and Multi-Sensor QPE (NMQ) System IPHEX dataset contains six different data products available as netCDF-4 and ASCII format files. The file naming convention for these data products are shown below.

Data files: <type>.YYYYMMDD.hhmmss.iPHEX.[nc|dat.gz]

Table 2: File naming convention variables

Variable	Description
<type>	1HGC: hourly rainfall accumulation 24HGC: daily rainfall accumulation MREF3D33L: 3-D reflectivity PRECIPRATE: precipitation rate SHSR: hybrid scan reflectivity VIL: vertically integrated liquid content
YYYY	Four-digit year
MM	Two-digit month
DD	Two-digit day
hh	Two-digit hour in UTC
mm	Two-digit minute in UTC
ss	Two-digit second in UTC
[nc dat.gz]	.nc: netCDF-4 file format .dat.gz: compressed ASCII file format

Data Format and Parameters

There are six data products within this dataset including rain rate estimates, hourly rain accumulation, daily rain accumulation, vertically integrated liquid content, hybrid scan reflectivity, and three-dimensional reflectivity. Tables 3 through 8 describe the variables within each of these data products.

Table 3: Data Fields for hourly rain accumulation (1HGC) netCDF-4 files

Field Name	Description	Data Type	Unit
accumulation	rainfall accumulation within last hour	float	mm
latitude	latitude	float	degrees N
longitude	longitude	float	degrees E

time	time	int	seconds since date and time given in filename
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Table 4: Data Fields for daily rain accumulation (24HGC) netCDF-4 files

Field Name	Description	Data Type	Unit
accumulation	rainfall accumulation within last 24 hours	float	mm
latitude	latitude	float	degrees N
longitude	longitude	float	degrees E
time	time	int	seconds since date and time given in filename

Table 5: Data Fields for 3-D reflectivity (MREF) netCDF-4 files

Field Name	Description	Data Type	Unit
latitude	latitude	float	degrees N
longitude	longitude	float	degrees E
mrefl_mosaic	3D reflectivity	float	dBZ
time	time	int	seconds since date and time given in filename
z	height above radar station	float	m

Table 6: Data Fields for rain rate (PRECIPRATE) netCDF-4 files

Field Name	Description	Data Type	Unit
latitude	latitude	float	degrees N
longitude	longitude	float	degrees E
precipitation_rate	precipitation rate	float	mm/hr
time	time	int	seconds since date and time given in filename

Table 7: Data Fields for hybrid scan reflectivity (SHSR) netCDF-4 files

Field Name	Description	Data Type	Unit
latitude	latitude	float	degrees N
longitude	longitude	float	degrees E
reflectivity	hybrid scan reflectivity	float	dBZ
time	time	int	seconds since date and time given in filename

Table 8: Data Fields for vertically integrated liquid content (VIL) netCDF-4 files

Field Name	Description	Data Type	Unit
latitude	latitude	float	degrees N
longitude	longitude	float	degrees E
time	time	int	seconds since date and time given in filename
vil	vertically integrated liquid	float	kg/m ²

	content		
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Algorithm

The derived data parameters were obtained using algorithms within the NMQ system as described in the ‘Product Description’ section above. More information about how these algorithms were developed and used to create the products are available in [Zhang et al., 2011](#).

Quality Assessment

Data from the WSR-88D radars were quality-controlled before using as inputs to the NMQ System. The quality control procedures remove non-precipitation echoes, including birds, insects, sun strobes, or residual ground clutter. More information about the quality control procedures are provided in [Zhang et al., 2011](#).

Software

These data are available in netCDF-4 and ASCII formats, so no special software is required to view the data in the files. [Panoply](#) can be used to easily view the netCDF-4 data files.

Known Issues or Missing Data

While these NMQ System products are improvements over other QPE products, there are still some challenges and issues. There is the difficulty in removing echoes at far ranges, where small convective cells are present and have similar local structure. In order to prevent removing snow or small storms at far ranges, the small echoes are not removed from the quality-controlled radar data used as inputs for the NMQ System.

The vertical resolution of the three-dimensional radar reflectivity data is coarser at far ranges. Due to this, discontinuities may appear in the three-dimensional reflectivity mosaic fields at heights where the vertical reflectivity gradients are strong; however, gap-filling radars are integrated into the NMQ system where possible to help with the data gaps.

Four reflectivity-rain rate relationships are used in the NMQ system to derive the precipitation rate product. Due to variations of these relationships over large areas and time scales, conditions may exceed what these four reflectivity-rain rate relationships can represent. Also, these relationships are relatively simplistic and errors caused by wind shear-induced drifting, locations of cloud-to-ground lightning, and convective precipitation have not yet been accurately accounted for.

More information about the known issues of the NMQ products is available in [Zhang et al., 2011](#).

Data Use Requirements

It is requested that users refer to the National Oceanic and Atmospheric Administration's (NOAA)/National Severe Storm Sentinel's (NSSL's) National Mosaic and QPE system when using or presenting these data in any public or scientific forum including conferences, workshops, meetings, technical reports, and publications. Details of data use requirements are provided below.

An appropriate reference to the 3-D reflectivity mosaics for publication and presentation purposes is:

Zhang, J., K. Howard, and J. J. Gourley (2005): Constructing three-dimensional multiple radar reflectivity mosaics: Examples of convective storms and stratiform rain echoes. *Journal of Atmospheric and Oceanic Technology*, 22, 30-42. doi: <https://doi.org/10.1175/JTECH-1689.1>

An appropriate reference to the 2-D products for publication and presentation purposes is:

Zhang, J., K. Howard, C. Langston, S. Vasiloff, B. Kaney, et al. (2011): National Mosaic and Multi-Sensor QPE (NMQ) System: Description, Results, and Future Plans. *American Meteorological Survey*, 92, 1321-1338. doi: <https://doi.org/10.1175/2011BAMS-D-11-00047.1>

Third-parties that wish to make use of the U.S. Government works should be aware of the provisions of 17 U.S.C. §403, in the event that the third-party claims copyright on the subsequent work. Section 403 encourages the Publisher to disclaim any copyright over U.S. Government works that are incorporated into larger works on which copyright is claimed.

Duplicating Analysis Methods in Order to Mimic the Dataset: Portions of the dataset were developed by the NOAA, U.S. Department of Commerce. For these portions, NOAA requests that users not duplicate analysis methods in order to mimic the dataset.

Excessive Revealing of Errors (related to this dataset) Without Communicating Findings to the Developers: Collaborators/Users are encouraged to communicate discovery of errors or other limitations of this dataset as means to constructively improve future Mosaic and QPE efforts.

Sharing these Data with Users Outside of the Intended Audience and Purpose: Users are requested not to share the data with other users, even within the same institute or group, without obtaining permission from the NMQ team at NSSL.

Holding the NSSL scientists liable for decisions, legal actions, or conclusions stemming from the use of the NMQ datasets: The NMQ datasets are being provided in-kind for the advance of science and the NSSL scientists shall not be held liable for decisions made in the provision of the data. Moreover, these data are experimental and subject to revision as improvements to processing algorithms are continually being made.

References

Benjamin, Stanley G., Dezso Devenyi, Stephen S. Weygandt, Kevin J. Brundage, et al. (2004): An Hourly Assimilation - Forecast Cycle: The RUC, *Monthly Weather Review*, 132, 495-518. doi: [https://doi.org/10.1175/1520-0493\(2004\)132%3C0495:AHACTR%3E2.0.CO;2](https://doi.org/10.1175/1520-0493(2004)132%3C0495:AHACTR%3E2.0.CO;2)

Zhang, J., K. Howard, C. Langston, S. Vasiloff, B. Kaney, et al. (2011): National Mosaic and Multi-Sensor QPE (NMQ) System: Description, Results, and Future Plans. *American Meteorological Survey*, 92, 1321-1338. doi: <https://doi.org/10.1175/2011BAMS-D-11-00047.1>

Related Data

All data from other instruments collected during the IPHEX field campaign are related to this dataset. Other IPHEX campaign data can be located using the GHRC HyDRO 2.0 search tool using the search term 'IPHEX'.

Contact Information

To order these data or for further information, please contact:

NASA Global Hydrology Resource Center DAAC

User Services

320 Sparkman Drive

Huntsville, AL 35805

Phone: 256-961-7932

E-mail: support-ghrc@earthdata.nasa.gov

Web: <https://ghrc.nsstc.nasa.gov/>

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